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ELECTRONIC TELEPHONE SWITCHES WITH TRANSISTORS

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ABSTRACT The electro-mechanical switches of usual telephone exchanges are required to perform one or more of the functions of selection under the control of impulses or of automatic hunting or of line finding during the setting up of a telephone connection. Transistorised switches which can perform all the above operations, have been described in the paper. Such switches can, therefore, be utilized with advantage in electronic telephone exchanges.

INTRODUCTION

All the existing automatic telephone systems, whether they be Strowger step-by-step systems or Cross-bar by-path systems or Panel Systems, use electro-mechanical switches and relays and all of them depend on mechanical contacts for establishing connections between different lines or trunks. Due to many disadvantages of these mechanical contacts such as wear due to use, corrosion due to sparks, constant attention required for their adjustments and cleaning etc and also due to the constant attention required for spring and other mechanical adjustments in the switches and relays, there has been a recent move to replace these mechanical parts by electronic devices and to get what is known as electronic telephone systems. (Flowers, 1950, 1951 and 1952; Heron *et al.*; 1951). The first electronic exchange using gas tubes is already in service at Morris (Chicago) in U.S.A and the first British electronic exchange is due to be ready for public service this year at the Highgate Wood in London. The former one uses space-division principle and the latter one uses time-division principle for operation. Although these electronic exchanges have been put into service, they are still worked on experimental basis and work is being carried out in U.K., U.S.A (Harris *et al*, 1950, Lewis, 1953 and Mathanel, *et al*. 1954) and in other countries (Ortvad, 1960) to find out a more suitable and reliable type of electronic exchange.

All the electro-mechanical systems use space-division principle in which connections are made between different transmission circuits through different switches and different trunks all occupying different positions in space. If the different operations required during setting up of connections by electro-mechanical switches can be performed by some electronic devices, all the electro-mechanical switches of the existing types of exchanges can be dispensed with. In this paper

some transistorised electronic switches which can perform all the above operations have been described and as such can be used in electronic exchanges.

Electronic devices have also made telephonic conversations possible between any two subscribers on other principles such as frequency-division and time-division principles These principles are more or less based on carrier working and so the system based on them requires complicated apparatus of carrier telephone systems. The system working in U.S.A. uses gas tubes for switching purposes on space-division principle and the system to be worked in U.K. employs time-division principle.

TELEPHONE SWITCHES AND THEIR OPERATIONS

There are many different types of switches used in different types of existing electro-mechanical systems such as uniselectors and two-motion selectors in Strowger system, cross-bar switches in Cross-bar by-path system, motor switches in Panel type system etc. These switches perform following two types of duties.

1. They are used for setting-up the required connections.
2. They are used as connecting paths for carrying out telephonic conversations.

Under the first item these switches are required to perform one or more of the following operations.

1. The desired line or the desired group of multiples are selected under the control of a number of impulses sent. This is called 'Selection' of a desired line or a group.
2. Automatic selection of the calling line is done without being under the control of any impulses when the subscriber takes up his telephone set. This is called 'Line finding' for a calling line.
3. Automatic selection of any free trunk out of a group of trunks is done without being under the control of any impulses. This is called 'Hunting' for a free trunk.

Electronic Switches employing transistors have been described here mentioning how all these different operations can be effected with its help. Connections for speech transmission can be made through other circuit devices which have not been dealt with in the paper.

ELECTRONIC DEVICES FOR SWITCHING

There are the following electronic devices which can be used for switching or getting connections between two lines.

1. Gas tubes.
2. Vacuum tubes.
3. Germanium or silicon diodes,
4. Transistors.

Of these, transistors and semiconductor diodes are most suitable due to their small sizes and small voltages required for their working for the purpose of use

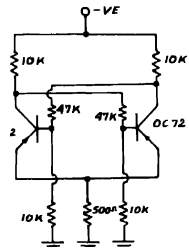

Fig. 1 Bi-stable circuit.

as telephone switches as quite a large number of switches are required in a telephone exchange. The well-known bi-stable circuit with transistors shown in Fig. 1, has been taken as the basic unit for building up such telephone switches. In such circuits with PNP transistors, when one conducts, the base of the other one becomes positive with respect to the emitter and so the other one does not conduct. If, however, a negative pulse is applied to the base of the non-conducting transistor, it becomes conducting and so naturally the base of the other one

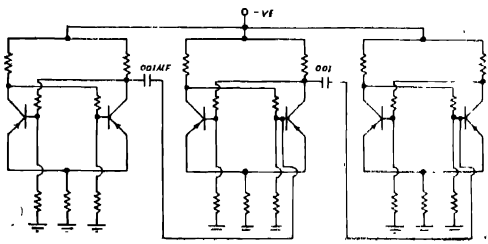

Fig 2 Switching circuit with bi-stable stage.

becomes positive and so it ceases to conduct. A switching circuit has been developed with the help of such bi-stable circuits three stages of which are shown in Fig. 2.

Different stages of bi-stable circuits are coupled through 0.001 microfarad capacitors connected between collectors of second transistors of previous stages and bases of second transistors of succeeding stages. Suppose that initially the second transistor B_1 of 1st stage is conducting and that the second transistors of all other stages B_2, B_3 etc are not conducting. If a negative pulse is applied to the base of transistor A_1, it will conduct and B_1 will cease to conduct. So the collector of B_1 becomes suddenly more negative and the negative pulse is applied

through 0.001 microfard capacitor to the base of B_2 transistor in the second stage and so B_2 transistor becomes conducting and its negative collector voltage is suddenly reduced. A positive pulse is therefore sent to the base of B_3 transistor but as B_3 transistor is already not conducting, this has no effect on it and so the third stage remains unaffected. If a second negative pulse is now applied to the base of transistor A_2 in the second stage, B_2 will become non-conducting and B_3 in the third stage becomes conducting in the same way.

TRANSISTORISED SELECTOR SWITCH

The above arrangement of bi-stable circuits can be used as a telephone selector switch with some modifications. In the case of usual selector switches, they are operated a number of times equal to the number of impulses sent by the dial from their home position where the wipers or moving elements return, as soon as the switch is released. In the present case the bi-stable circuits are so arranged that

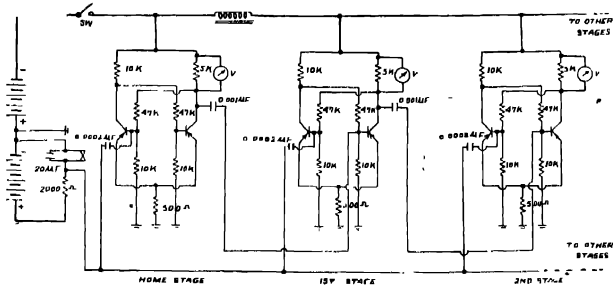

Fig 3. Selector switch.

when the supply voltage is connected to all of them, always the second transistor of the first or home stage conducts and the first transistors of all other stages conduct. This is achieved by connecting slightly different values of resistance in the collector circuits of the two transistors in a stage and by giving the supply to all the subsequent stages except the first one through a suitable choke as shown in Fig 3.

With unsymmetrical bi-stable circuits as shown in the figure if the supply voltage is suddely applied, the second transistor conducts, but if the supply voltage is applied by gradually increasing its values, it is the first transistor which starts conducting. If the collector supply voltage to all but the first stage is applied through a suitable value of choke as shown in the figure, when switch SW is operated, the second transistor of home stage starts conducting and the first transistors of all the other stages start conducting. This switch SW may be operated by the dial off normal spring contacts of the dial.

The bases of first transistors of all the stages are connected to the dial impulsing contacts through condensers of values of 0.0002 microfarad. When these

spring contacts are operated, negative impulses are sent and applied to the bases of all the first transistors of all the stages Initially the first transistors of all the stages except the home stage are conducting and so their conditions will not be changed. The first transistor base, however, becomes negative with respect to emitter and it starts conducting and the conditions are changed in the home stage resulting in change in the condition in the first stage only. If another impulse is sent now, the condition of first stage is now changed resulting in a change also in the second stage. Thus if a number of impulses are sent, there will be change in the condition of the bi-stable stage of the corresponding number and its second transistor will be conducting and no other second transistors of any other stage will be conducting. Thus selection is possible among the different stages by dialling any particular number and the entire arrangement can be used as a selector switch.

In order that bi-stable operations are effective, the pulses of voltage or current that are applied, must be very sudden i.e. the rate of change of voltage or current must be very high. In a pulse there is one front edge and one back edge and if both of these edges be equally sharp, the previous initial condition will come back when the entire pulse is sent. In order that one condition is changed only by the sending of one pulse, it is necessary that one edge of the pulse should be sharp and the other edge be gradual. This is achieved by having a suitable high capacitor in series with a suitable resistance across the impulse sending battery and by connecting the dial impulse springs across the capacitor. Initially the capacitor is shorted by dial impulse springs. When these impulse springs break, the condenser is charged through the resistance and a gradually rising front edge of the impulse is obtained and it is so gradual that it can not effect any change in the states of

Fig. 4. Nature of wave shape.

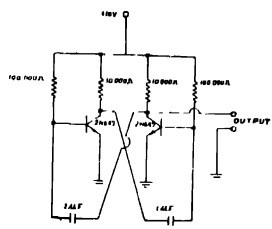

Fig. 5. Astable multivibrator.

any bi-stable stage. When the impulse spirng contacts remake, the charged condenser is suddenly shorted and discharged and the back edge of the impulse abruptly

decreases to zero and this is effective in bringing about a change in the state of the home stage mutually and of other stages subsequently. The nature of the impulses sent is shown in Fig 4.

TRANSISTORISED LINE FINDER SWITCH

The selector circuit shown in Fig. 3, can be used as a Line Finder circuit if we replace the dial and its associated equipments by an astable multivibrator circuit shown in fig. 5.

N.P.N. transistors type No. OC 647 are used in the multivibrator circuit so that nature of pulses with sharply falling end edges as shown in Fig. 4, are obtained. The values of capacitances and resistances are so chosen that pulses at the rate of 10 per second which can operate the bi-stable circuits without fail are obtained. When the output of such a multivibrator circuit is connected through 0 0002 microfarad capacitors to the bases of first transistors of all bi-stable stages, the states of different stages are changed one after another by the impulses sent from the astable multivibrator and if the last stage is coupled to the first stage by a coupling capacitor,the states go on changing one after another continuously. If now a capacitor of appreciable value, say 0.01 microfarad is connected across the resistance of 10K joined between the base and earth of the first transistor of any stage (Fig 3)., as soon as the second transistor of this stage conducts, there cannot be any further change of conditions in any stage and no second transistors of any other stage can be made to conduct afterwards even by the connection of a similar capacitor across similar points in any other state Thus the selector switch can be used for line finding action satisfactorily. If the capacitor connection is made by the lines of the subscriber when he takes up his telephone from the cradle, then the second transistor of the bistable circuit corres-ponding to the line continues conducting and the hunting action stops and if any other subscriber takes up his telephone set subsequently, the transistor of the bistable circuit corresponding to the second line does not conduct also. When a condenser of appreciable value is connected as above, pulses from the multivibrator are bi-passed through it and so they cannot effect any further change of states.

TRANSISTOR HUNTER SWITCH

Bi-stable circuits with slight modifications are used for different stages and the astable multi-vibrator circuit referred to above may be used for driving the switch circuit as shown in Fig. 6.

If a free trunk is indicated by the presence of earth on the emitter of the second transistor of the stage corresponding to the line, then as impulses are sent from the multivibrator , the second transistor of the stage corresponding to the trunk conducts and it continues to conduct so long as earth is present. When the emitter of the second transistor which conducts is earthed, it cannot be made positive with respect to emitter and so hunting action stops If there is no earth present on the

emitter of the second transistor of any stage, then the bi-stable stage is unaffected by impulses which are by-passed to the next stage. If any trunk is busy, the

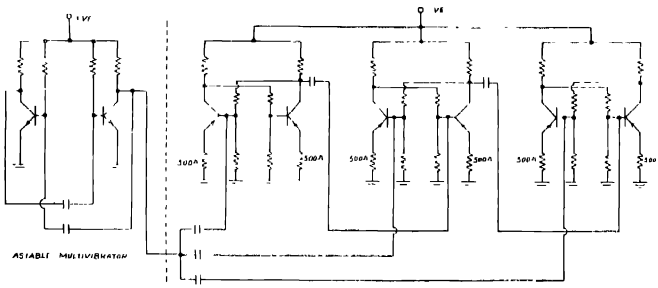

Fig. 6. Trunk switch

purpose is served if there be no earth connected on the emitter of the second transistor corresponding to the trunk. Due to the emitter being given a negative bias, the negative impulse can not produce any change in the state It is applied, however, through the coupling condenser to the base of the second transistor of the next stage and if earth is present on the emitter of his transistor, the impulse effects a change in the state of this latter stage.

CONCLUSION

These transistorised switches can thus perform all the important functions of usual electro-mechanical switches of telephone exchanges so far as selection of the required line or group of trunks is concerned during setting up of a telephone connection Therefore, they can be utilised in place of such switches in existing types of exchanges and the complicated circuits required for having electronic exchanges on principle of carrier working or time division system, may be avoided. Speech circuits may be provided by using other transistors or gas tubesor even saturable reactors and they may be operated by the transistorised types of switches described here.

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